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Back Radiation Suppression through a Semitransparent Round Ground Plane for mm-Wave Omnidirectional Antennas

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1. Abstract

Omnidirectional radiation pattern with minimum backward radiation is highly desirable for millimeter-wave telecommunication antennas. In this work, we propose a round, semitransparent ground planes of radius 0.8λ with uniform impedance distributions that can improve the front-to-back ratio of a wideband patch antenna by 11.6 dB and reduce the back radiation of a monopole antenna by 8.8 dB as compared with a similar sized metallic ground plane. The values of uniform impedance are obtained through analytical optimization by using asymptotic expressions in the Kirchhoff approximation of the radiation pattern of a toroidal wave scattered by a round semitransparent ground plane [1].

2. Design

A stacked wide-band patch antenna [2] and a monopole with round, semitransparent (Fig. 1 (a), (c)), and metal (Fig. 1 (b), (d)) ground planes with a radius of 8 mm were fabricated and measured to verify the results of optimization. The patch has two dielectric layers of the Rogers RO3003 laminate with a thickness of 0.5 mm and a radius of 3.8 mm for each layer. Each layer has a square metal plate with angled circular cutouts. The lengths of the bottom and the top squares are 2.85 and 2.65 mm respectively. The radius of all cutouts is 0.95 mm. The patch is excited by a 50-Ω coaxial cable, which is located 0.78 mm from the axis of the patch. The central core of the coaxial cable has electric contact with only the bottom plate. The monopole in the form of cylinder with radius of 0.4 mm (Fig. 2) has the total length of 2.4 mm, where the conical base has a radius 0.25 mm and a length of 1.3 mm. The monopole is excited by a 50-Ω SMA connector. The semitransparent ground plane was fabricated by spreading a thin layer of low-cost carbon paste with uniform thickness on a thin Kapton film. The value of the impedance and the inner radius of the semitransparent surface is 70 Ohm, 3.8 mm and 129 Ohm, 3 mm for the patch antenna and monopole, respectively.

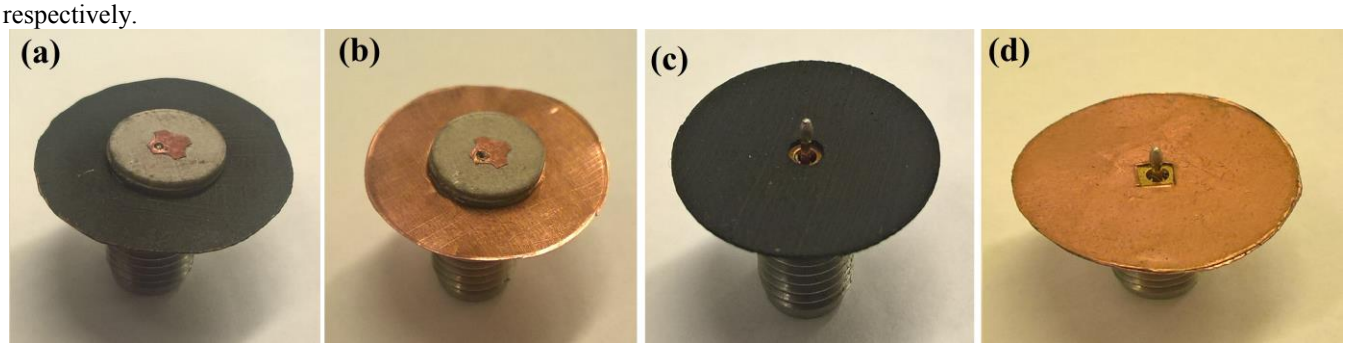

Figure 1. Photos of the fabricated patch antenna with semitransparent (a) and metal (b) ground plane and the monopole antenna with semitransparerent (c) and metal (d) ground plane.

3. Conclusions

Thus, using the model of the scattering of a toroidal wave by a round, semitransparent ground plane for the optimization of transparency of the ground plane has allowed us to determine the values of uniform isotropic resistive impedance that provide low level backward radiation of the patch antenna and the monopole with the ground plane. The proposed antennas with the semitransparent ground plane may be used as 5G antennas.

4. References

1. V. Kaloshin and K. Klionovski, "On Radiation of Omnidirectional Axisymmetric Antennas with Circular Ground Planes," *Journal of Communications Technology and Electronics*, vol. 60, no. 10, pp. 1062–1071, Oct. 2015.